Response to Petition for Rulemaking, submitted by William Kurtz, Mercedes-Benz USA LLC, on April 4, 2003.

I am writing to provide comment on the above petition because as a researcher I have recently completed, with the help of my colleagues, a three and one-half year study directed at development of enhanced rear lighting and signaling for motor vehicles. The opinions I shall express are my own and do not necessarily reflect those of my colleagues or other persons, the organization for which I work, or the agency that sponsored the research. I shall try to be brief.

Our research suggests that while the proposal contained in the petition may have merit, it also creates some difficulties for more broadly based changes in rear lighting. We started with the idea that while the current lighting system on light vehicles may not be perfect, it is well understood by drivers and useful to them. Furthermore, any changes must demonstrate clear advantages and no disadvantages. In addition, the ramifications for phase-in must be carefully considered and must not detract from eventual full deployment. Consequently, in our research the concept of "additional" signaling was given priority. Here, the idea is that any enhancements which do not alter the current configuration should be given priority. That way, there is less likelihood of confusing the driver, because the driver can always rely on the original lighting to obtain the basic information on marking (location) of, and brake application by, the lead vehicle.

Briefly, we have developed a relatively simple "added" rear signaling (lighting) system which has been shown in realistic closed-course driving using ordinary drivers to produce approximately 0.3 second of improvement in response time to emergency braking by lead vehicles. This braking improvement is under realistic conditions in which the driver is distracted by an in-vehicle task. The added signaling would be activated in one of two ways: open-loop or closed-loop. For open-loop use, the threshold for triggering activation would be set at 0.35g of deceleration. When deceleration drops below 0.15g, a timeout feature would continue the activation for a period of 5 seconds. Thus, a lead vehicle that braked relatively hard to a stop would maintain its enhanced lighting for a period of time following the stop, during which it is most likely to be struck. In the closed-loop situation a radar or similar system would measure the closing rate and distance of the following vehicle and would then compute whether or not a collision is likely. It would then activate the enhanced lighting when a collision is likely. Note specifically that the resulting open-loop system would "catch" a much greater number of rear-end crashes than the Mercedes-Benz USA system, because the threshold for deceleration is much lower for activation. There would be some false alarms. However, the time length of the stimulus in any case is relatively short, and we have determined that ordinary drivers consider the stimulus to be tolerable. On the other hand, if the more complex closed-loop approach is implemented, there should be a very high probability of correct activation and very few false alarms.

Crash database studies show that the majority of rear-end crashes occur in daylight under good driving conditions. Furthermore, the majority occur with the driver looking away from the forward view, either somewhere else outside the vehicle or into the vehicle. In a few cases the driver is looking forward, but not perceiving the situation (for example, daydreaming). Our original hypothesis was that the major problem is “getting the driver’s attention”. Therefore, the primary consideration is maximizing the probability of detection by the following driver. This appears to be best accomplished by a high brightness stimulus. Thereafter, the driver must intuitively recognize the stimulus as an imminent crash warning.

Our research began by testing 17 different configurations prior to settling on a final “best” configuration. The optimum “imminent crash warning signal” is a single high-output halogen lamp with a motorized reflector and a non-dispersive red-tinted lens. The reflector is driven in an M-sweep pattern. This system measures 4.7 in (11.9 cm) wide by 3.7 in (8.8 cm) high by 3.8 in (9.6 cm) deep. The M-sweep pattern causes the bright lamp output to “cross the driver’s face” creating a strong stimulus intended to redirect the driver’s attention. Our research suggests that conventional brake lights are of insufficient brightness in daytime to redirect the driver’s eyes to the forward view. A lamp of much greater luminance output must be used under these conditions. In a final implementation, however, the lamp output would need to be attenuated under nighttime or subdued light conditions. This could be accomplished by means of an ambient illumination sensor and corresponding pulse width modulation of the lamp drive voltage. I should mention that the 17 configurations included several suggested by lighting/vision experts. The configurations included multi-lamp steady and flashing concepts, multi-strobe lamp arrangements, and a variety of simpler designs. The optimum signal is referred to as a TCL (traffic clearing lamp). Our data demonstrate that drivers who had never seen this lamp before were able to recognize it as a braking emergency signal. As indicated, their brake response was approximately 0.30 second faster and their stopping distances were also shorter even though they had never encountered a vehicle equipped with the system previously.

An improvement of this type can be shown analytically to result in an improved stopping distance of approximately 20 ft. (6.1 m). It is estimated analytically that roughly a 20% reduction would occur in the rear-end crash rate, and that for the remainder, there would be a substantial reduction in kinetic energy on impact. Because the system is more universally applicable than the Mercedes-Benz USA-proposed system, it should have a greater effect on crash reduction.

I should mention that while the results obtained in our research are promising, we had hoped to achieve approximately 0.5 second (or more) reduction in response time for preoccupied drivers. However, our experience in full scale testing indicates a perceptual narrowing component in driver behavior. Specifically, our research suggests that when drivers become pre-occupied with an in-vehicle task, they tend to suppress peripheral vision, which in this case includes the forward view. Consequently, imminent crash warning signals that are at the rear of the lead vehicle are to some extent suppressed by the driver of the following vehicle. One of the remedies for this would be to use an inexpensive radio link in which an unambiguous auditory warning is transmitted to the interior of the following vehicle. This would require directional antennas on both the rear of the lead vehicle and the front of the following vehicle to reduce noise pollution and false alarms. Others have studied auditory crash warning signals (Kiefer *et al*, 1999). However, the trick in this case is to keep the cost down while providing a clear, unambiguous auditory warning that would supplement the visual imminent crash warning signal at the rear of the lead vehicle. It should be noted that a phase-in approach is possible, in which the visual warning is implemented first, to be followed later by the addition of a radio (or other type of) simple one-way communication link. This sequential approach should produce cost-effective results. Our transportation system currently relies on the driver to avoid rear end crashes. As long as this situation remains, the above proposal probably represents the best approach to reducing the very high rate of rear-end crashes.

The final report for our research will be published in the near future. Earlier reports and papers are already available and are included in the reference list below. The final report recommends a plan of action that includes small refinements and subsequent fleet testing. While no one knows for sure what would happen in fleet tests, I believe there is a high probability of rear-end crash reduction for the equipped vehicles.

For the reasons stated, therefore, I have concerns about the Mercedes-Benz USA proposal. My specific concerns are:

1. The proposal changes the existing lighting system, which drivers have learned to use. Theoretically, any number of proposals might be forthcoming that would involve changes to the current lighting standard. These may cause confusion among drivers.
2. While having merit, the proposal covers only a very high level of deceleration. Consequently, it would miss large numbers of rear-end crashes.
3. A more comprehensive approach may pay higher dividends in rear-end crash reductions.

Respectfully submitted,

Walter W. Wierwille, Ph.D., P.E.

References:

Kiefer, R., LeBlanc, D., Palmer, M., Salinger, J., Deering, R., and Shulman, M. (1999). *Development and Validation of Functional Definitions and Evaluation Procedures for Collision Warning/Avoidance Systems.* Report DOT-HS-808-964. NHTSA, U.S. Department of Transportation.

Lee, S. E., Wierwille, W. W., and DeHart, M. C. (2003). The Evolution of an Enhanced Rear Signaling System. Paper presented at the *2003 Transportation Research Board Meeting*, Washington, D.C. (CD-ROM). See also *Transportation Research Record* Number 1843, pp. 31-40, 2003.

Lee, S. E., Wierwille, W. W., and Klauer, S. G. (2002). Enhanced *Rear Lighting and Signaling Systems: Literature Review and Analyses of Alternative System Concepts (Task 1 Final Report).* Report DOT-HS-809-425. NHTSA, U.S. Department of Transportation.

Wierwille, W. W., Lee, S. E., and DeHart, M. C. *Enhanced Rear Lighting and Signaling Systems: Testing and Optimization of High-Level and Stopped/Slowly-Moving Vehicle Rear Signaling Systems (Task 2 Final Report)*. Report DOT-HS-809-597. NHTSA, U.S. Department of Transportation, 2003.

Wierwille, W. W., Lee, S. E., and DeHart, M. C. *Enhanced Rear Lighting and Signaling Systems: Project Final Report; Test Road Experiment on Imminent-Warning Rear Lighting and Signaling.* Final Report, Contract No. DTNH 22-99-C-07235. (To appear as a NHTSA-published report, March, 2004.)